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STRUCTURE OF PORCELAIN PASTES AND GLAZES MADE FROM GUSEV DEPOSIT STONE

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The structure of porcelain and glazes made from Gusev deposit stone was investigated. Its positive and negative effect on the quality of porcelain articles was demonstrated.

The wide use of slip casting is characteristic of production of Gzhel porcelain due to the complex shapes of Gzhel articles and the large number of attached parts. At the same time, it became necessary to develop a porcelain paste composition designed for plastic molding to increase the volume of flat articles and reduce manufacturing wastes. An unconventional complex raw material was selected as one component for developing the composition of the plastic paste – porcelain stone from the Gusev deposit – due to the low content of iron and titanium compounds combined with properties of plasticity.

A normal-basic variety of Gusev stone of the following chemical composition (%) is used at Gzhel Association Co.: 76.53 SiO_2, 16.58 Al_2O_3, 1.55 K_2O, 0.72 TiO_2, 0.42 CaO, 0.24 Na_2O, 0.14 Fe_2O_3, 0.30 MgO, 3.52 calcination loss. The mineral composition is (%): 33.0 kaolinite, 52.5 quartz, 14.5 feldspars, hydromica, etc.

The porcelain paste made from Gusev stone was characterized by high molding indexes which allowed manufacturing articles with thinner walls and low process wastes. In addition, the improvement in the consumer properties such as whiteness (it increased by 6% in the experimental paste in comparison to conventionally produced paste (according to Spekol) and the brightness according to the LAB system increased by 4% and reached 83.53). The developed paste was distinguished by a lower TCLE than the commercial paste (the TCLE for the experimental paste was $5.2 \times 10^{-6}\ K^{-1}$ in the 20 – 400°C temperature range). Two colorless glazes with reduced TCLE were also made from Gusev stone. The TCLE of the experimental glazes were 5.2×10^{-6} and $4.7 \times 10^{-6}\ K^{-1}$.

The structure of the porcelain [1 – 3] was investigated with a set of equipment designed for sample preparation (microsections and polished sections) and analysis. As a result of the microscopic study, the quantitative phase composition of the porcelain and glazes was determined: pores in reflected light on polished sections (× 100, 200) and quartz in transmitted light on polished sections (× 100, 200). In the automatic mode, the accuracy of determination was ± 2% and in the traditional mode it was ± 5%.

The residual quartz in the Gusev stone material persisted in a smaller amount than in the conventionally manufactured porcelain; it differed by the peculiar isometric shape, small particle size, and normal grain fusion (Fig. 1*a*). The porosity of the experimental material was higher, with pores close to isometric shape and of smaller size. The homogeneity of the

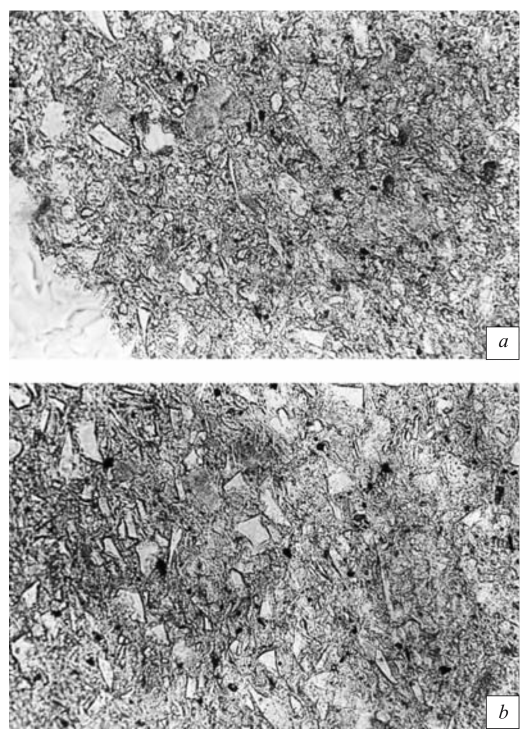

Fig. 1. Structure (× 284) of porcelain based on Gusev stone (*a*) and commercial porcelain (*b*).

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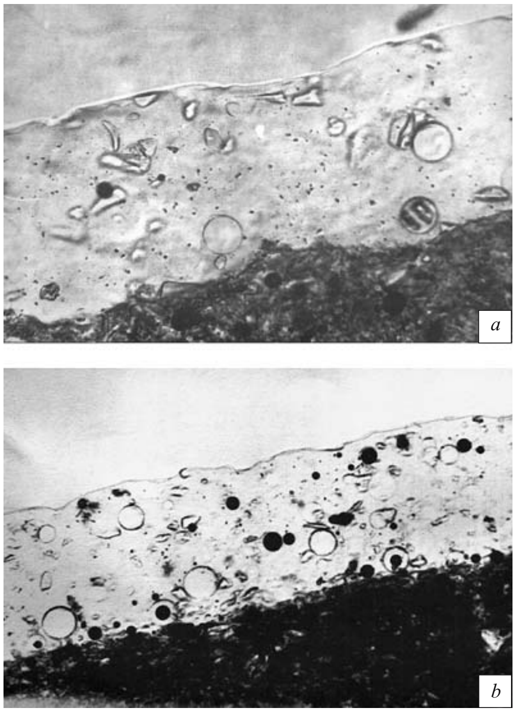

Fig. 2. Structure of glazes: *a*) commercial (× 310); *b*) experimental (composition 2, × 156).

material was much better. This is also related to mullitization – the mullite in the porcelain paste made from Gusev stone is more uniformly developed not only in the basic paste but also in pseudomorphoses with respect to feldspar in which the mullite crystals are smaller and form a thick network (see Fig. 1).

The almost total absence of quartzite grains in the crystalline phase of the glaze, where undissolved ground quartz sand grains primarily remained, should be noted for the glazes made from Gusev stone both for the normal glaze layer thickness (100 – 110 μm – as in most colorless porcelain glazes) and for a large layer thickness (240 – 250 μm) (Fig. 2). The gas phase in the glazes based on Gusev stone is located in larger pores (maximum diameter of up to 100 – 180 μm) in comparison to the commercial glaze. The contact layer on the glaze–porcelain boundary was similar in character for both the experimental and the commercial glazes. The characteristics of the structure of the porcelain and glaze are reported in Tables 1 and 2.

The use of Gusev stone for preparation of porcelain glazes and paste thus led to the appearance of unusual structures which in turn was reflected in the consumer properties of these materials. For example, due to an increase in the number and size of the pores in the glazes made from Gusev stone, the proportion of gas phase increased, which was sometimes accompanied by the appearance of the "orange skin" defect on the surface of the glaze coating.

The undoubted advantage of the structure of Gusev stone porcelain is its homogeneity and lower tendency toward par-

TABLE 1

Microstructure parameters	Glaze		
	commercial	experimental No. 2	experimental No. 3
Glaze thickness, μm	100 – 110	100 – 110	240 – 250
Residual undissolved quartz:			
amount, %	4.0	4.3	6.6
average size, μm	13.0	10.7	11.5
Porosity, %	4.5	8.5	7.0
Pore size, μm:			
average	26	33	25
maximum	60	100	180
Size of mullite needles on porcelain–glaze contact layer boundary, μm	Up to 10	10 – 15	5 – 10

TABLE 2

Microstructure parameters	Paste	
	commercial	experimental
Residual quartz:		
amount, %	13.0	11.0
average size, μm	16.2	10.7
width of quartz grain fusion edge, μm	1 – 2	1 – 2
Porosity, %	6.4	7.8
Average pore size, μm	9.8	8.9
Size of mullite crystals, μm:		
in basic paste	1	1
in pseudomorphoses based on feldspar	2 – 15	2 – 10

ticle orientation due to the unique almost isometric shape of the quartzite grains. This led in practice to improvement of the molding properties of the ceramic pastes made from Gusev stone. Due to the higher reactivity of the quartzites in the structure of the Gusev stone porcelain paste, more glassy phases are formed, which causes more homogeneous mullitization and increases the whiteness of the experimental material.

The structure of the glazes containing Gusev stone is characterized by high dissolution of quartzites in the glass phase, which in particular decreases the TCLE. This will allow developing different kinds of glazes from Gusev stone.

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